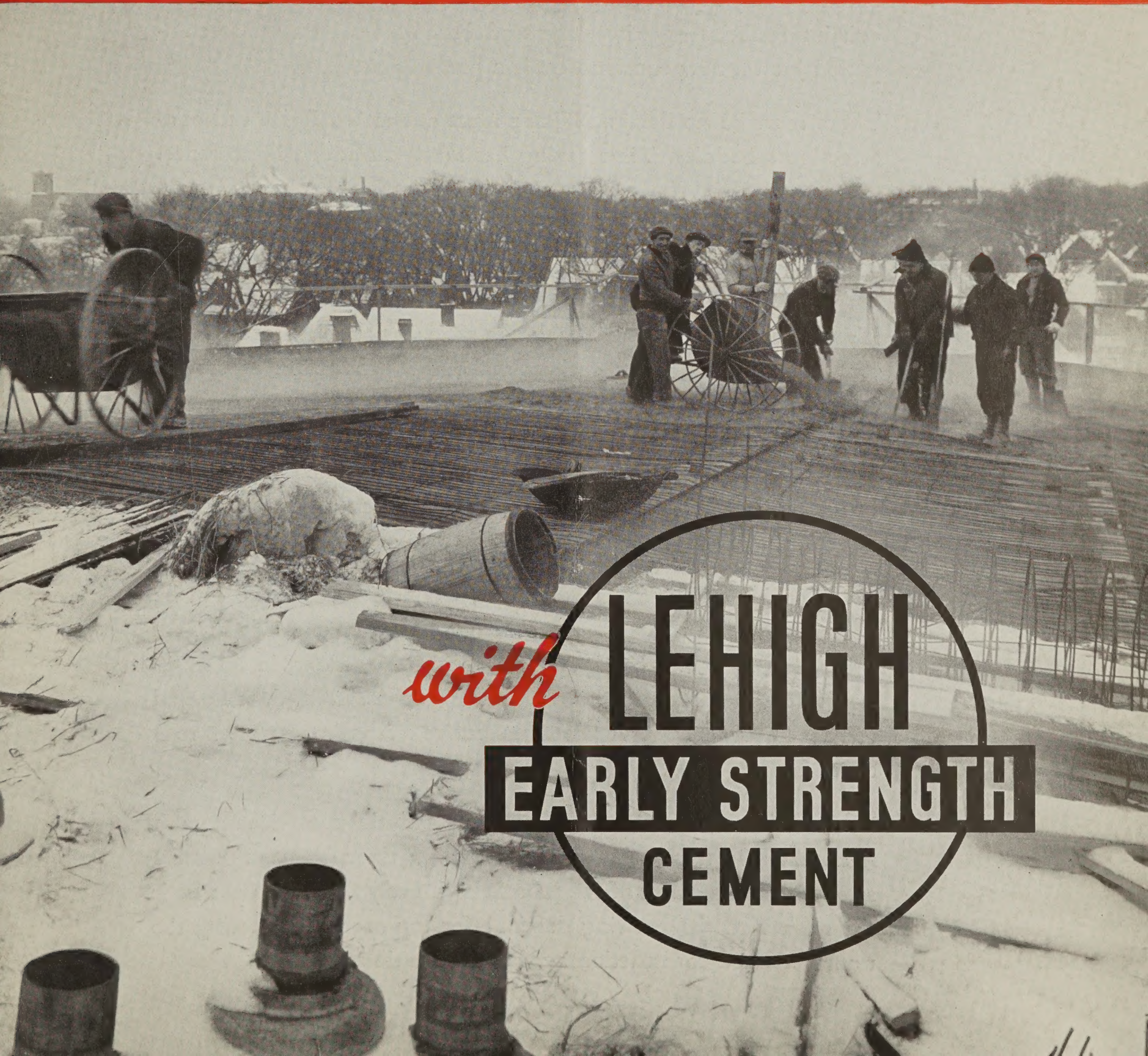
Cold Weather Concrete



with LEHIGH EARLY STRENGTH CEMENT

WINTER concrete at summer speed

Construction tempo is rapidly changing with America's call for speed—and more speed.

Already many industries are operating close to practical capacity of existing facilities—getting top speed from blue print stage to completed job on new construction is a pressing problem.

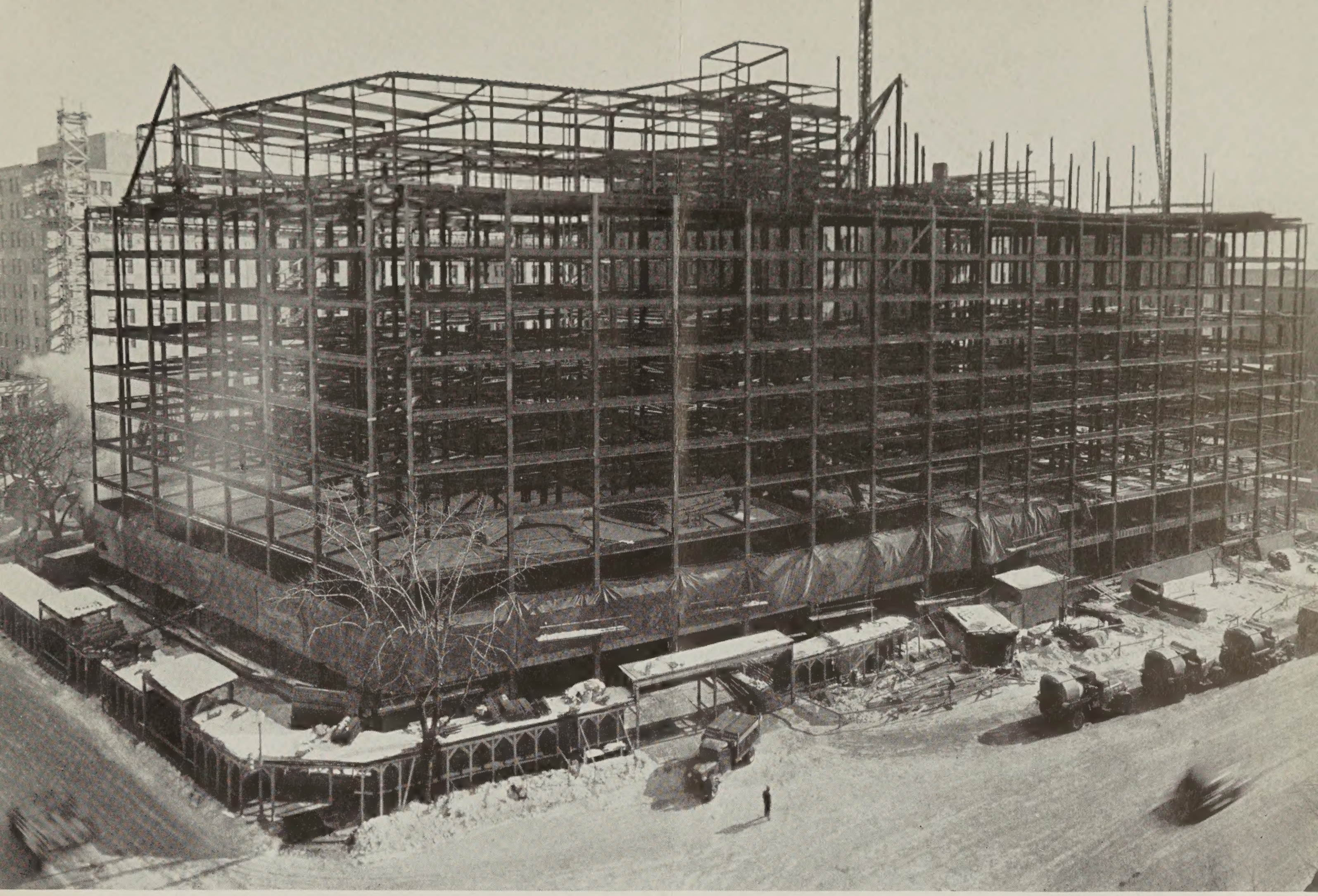
There must be no delays. Winter must not retard full speed construction schedules. Time saving has taken on added importance.

How fast a job moves often depends upon the time it takes to produce service strength concrete. In cold weather, the rate of concrete hardening is slowed up—at 32° it practically stops.

Heating the concrete mixture, heat protection against frost damage and maintained during curing, make the production of service strength concrete possible at summer speed. But the cost must be reckoned—salamanders, enclosures, fuel, extra labor, fire hazard. Obviously the faster concrete cures, the shorter is the required time of heat protection, the lower is the cost. And, more important, the quicker the job progresses.

With Lehigh Early Strength Cement, winter-time concrete can be produced with a reduction of from one-half to two-thirds in heat protection time and cost. Under identical conditions, in 24 to 48 hours Lehigh Early Strength Cement equals the strength of normal cement at seven days. It produces service strength concrete 3 to 5 times faster.

In the coldest weather, with adequate precautions, service strength is obtained in 24 to 72 hours, depending upon the compressive strength requirements of the job. Lehigh Early Strength Cement is the answer to the pressing demand for top speed in meeting the unprecedented construction needs of the nation.



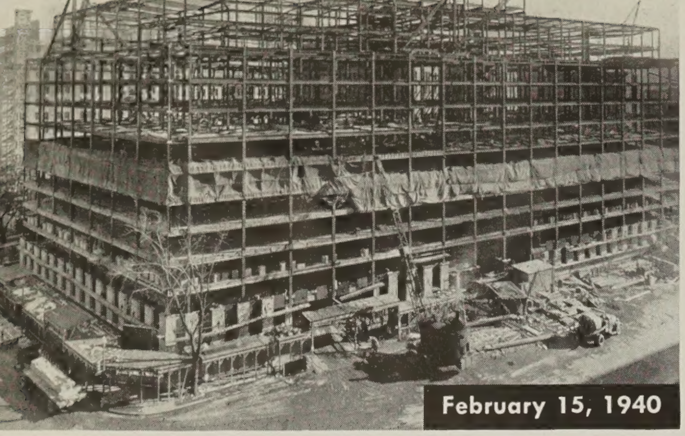
LAFAYETTE BLDG., 15th & I Sts., N. W., Washington, D. C. **ARCHITECTS:** A. R. Clas & Associates, Washington, D. C. Holabird & Root, Chicago, Ill. **ENGINEER:** A. J. Scullen, Washington, D. C. **GENERAL CONTRACTORS:** Thompson-Starrett Co., New York. **CONCRETE CONTRACTORS:** Senn-Herrick Corp., New York.

A PRACTICAL CASE

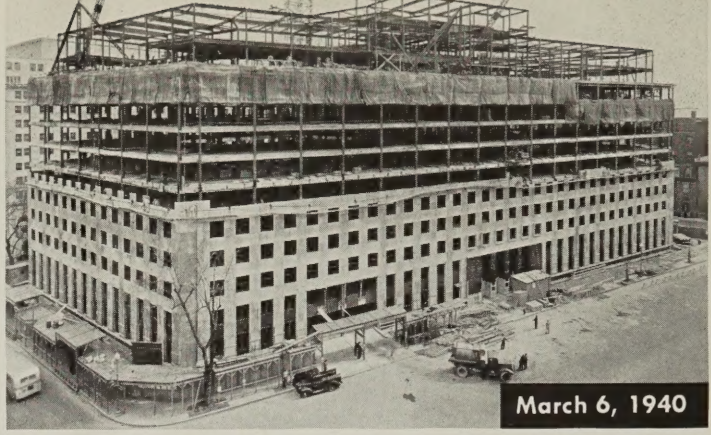
The winter-time completion of the Lafayette Building in Washington, D. C., demonstrates how the use of Lehigh Early Strength Cement can beat a summer-time schedule for normal cement concrete.

Steel erection was finished and forms were erected for starting the construction of the concrete floors. Method and schedule were worked out for the use of normal portland cement. A sudden demand for early occupancy upset the plans, required a "stepped-up" schedule.

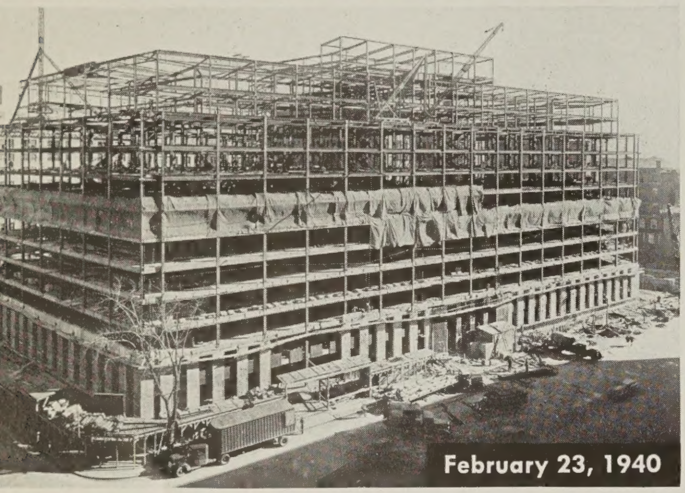
By switching to Lehigh Early Strength Cement, the concrete basement, twelve floors, and roof slab were completed in 8 weeks. In addition to the time saving, impressive economies are shown by the record.



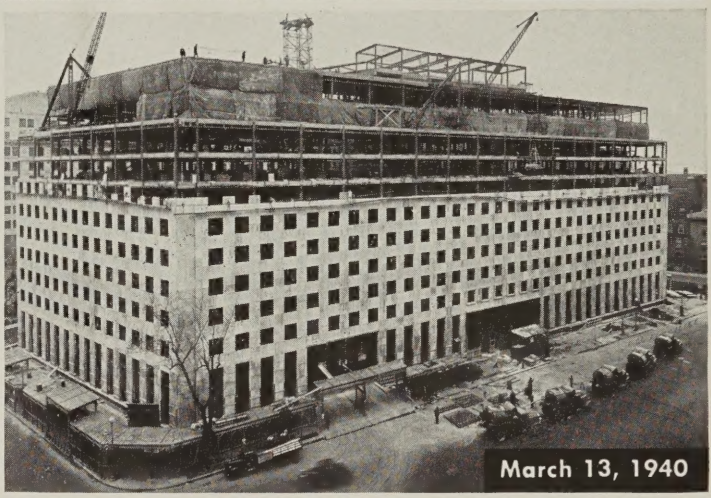
February 15, 1940



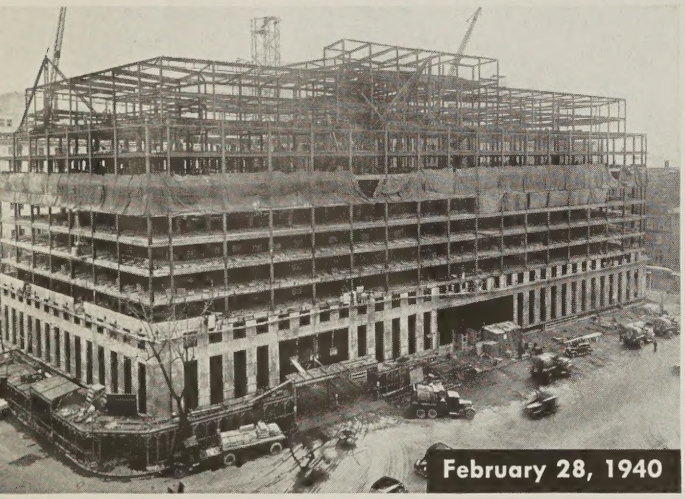
March 6, 1940



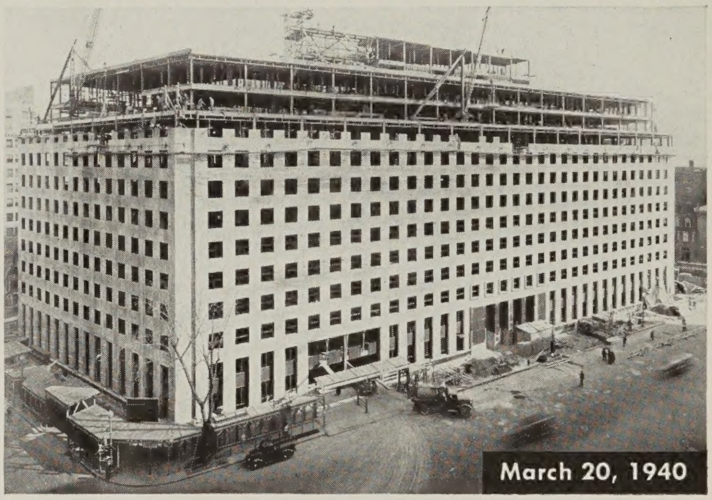
February 23, 1940



March 13, 1940



February 28, 1940



March 20, 1940

Concrete Requirements

13,500 cubic yards of Washington, D. C., Class B concrete which required a compressive strength of 2500 p.s.i. at 28 days. 80% of required 28-day strength to be attained before stripping forms.

Forms were removed in only 4 days, concrete having quickly cured to required strength. No reshoring of floors was necessary. Compared with normal cement, this gave 10 to 17 days' earlier use of concrete (form removal in 4 days instead of from 14 to 21 days). Had original plans provided for quick service concrete, savings on form costs would also have been noteworthy.

Heat Protection

Temperature of concrete when placed was from 50° F. to 100° F. depending upon outdoor temperature. Curing areas were confined by tarpaulins and heated by salamanders. Curing temperature at eye height from floor was maintained at about 70° F. Heat curing was continued until time for form removal.

Compared with normal cement, duration of heat curing was cut more than half. At $200 per day curing cost, this represented a big economy.

Construction Expedited

Quick use of concrete allowed other trades to use concrete floors as working bases 10 to 17 days sooner. Progress photographs with dates show the speed of construction. Exterior walls and interior construction proceeded uninterruptedly—no long waiting for concrete to cure—only 8 weeks for all concrete in the superstructure—faster than a normal summer-time schedule. This "stepping up" correspondingly reduced job overhead.

Concrete in cold weather

Time and cost are the two factors which usually will determine the selection of Lehigh Normal Cement or Lehigh Early Strength Cement for any type of concrete work.

It is important to remember that at any season concrete made with Lehigh Early Strength Cement cures to service strength 3 to 5 times faster than concrete made under the same conditions with normal cement.

Urgency, regardless of any other factor, often dictates the use of Lehigh Early Strength Cement. On the other hand, its use often results in lower form costs, curing costs and overhead when quick completion is not a factor.

For any job, it is advisable to work up two schedules—one contemplating the use of Lehigh Normal Cement and the other, Lehigh Early Strength Cement. Comparison will demonstrate whether or not quick service concrete can be used to advantage.

In cold weather schedules, the savings with Lehigh Early Strength Cement are particularly notable. In 24 to 48 hours, under similar conditions, Lehigh Early Strength Cement equals the strength of normal portland cement at 7 days. Every day's reduction in the length of time during which concrete must be cured by artificial heat shows a sizable saving in cost.

On the opposite page, a comprehensive tabulation of recommended procedure with Lehigh Early Strength Cement will assist in determining the advantages of quick service concrete for specific types of work at low temperatures. In this booklet are also shown data which will be helpful in determining winter-time procedure to get top speed with economy, for any concrete.

Lehigh Service Engineers are always available for consultation on any specific problems.

RECOMMENDED PRACTICE WITH
LEHIGH EARLY STRENGTH CEMENT

Procedure recommended is based upon the following: **1. Minimum water content to provide necessary workability and desired strength.** **2. Minimum heat loss after mixing.** **3. Moist curing.**		**Heavy sections, such as foundations, piers, retaining walls, dams and other mass construction.**	**Roads, streets, sidewalks and other surface construction.**	**Thin sections, such as beams, columns and other exposed work.**
		With Lehigh Early Strength Cement. A.S.T.M. Specification C 150-40 T Type III.	**With Lehigh Early Strength Cement. A.S.T.M. Specification C 150-40 T Type III.**	**With Lehigh Early Strength Cement. A.S.T.M. Specification C 150-40 T Type III.**
For Cool Weather When Temperatures Do Not Fall Below 40° F.	**Protection of Materials**	Aggregates free of frost. Heated aggregates not necessary. Heated water will accelerate curing.	Aggregates free of frost. Heat water — not above 180°-190° F.	Aggregates free of frost. Heat water — not above 180°-190° F.
	Temp. of Concrete when placed	60° F.	70° F.	60° F.
	Curing period	12 to 24 hours	12 to 24 hours	12 to 24 hours
	Protection during curing period	Under canvas or straw to retain heat.	Under canvas or straw to retain heat.	Use canvas tarpaulins and straw covering to retain heat.
	Service strength at	24 hours	Light duty in 36 hours. Heavy duty in 72 hours.	48 hours
For Cold Weather When Temperatures Range Between 40° F. and 20° F. Minimum	**Protection of Materials**	Heat all water and aggregates. Water not above 180°-190° F. Remove all snow and ice from forms.	Heat all water and aggregates. Water not above 180°-190° F. Deposit concrete on subgrade free of frost.	Heat all water and aggregates. Water not above 180°-190° F. Deposit concrete in forms free of ice and snow. Warm forms with steam if available.
	Temp. of Concrete when placed	70° F.	80° F.	80° F.
	Curing period	18 to 48 hours	24 to 48 hours	24 to 48 hours
	Protection during curing period	Provide heat if possible—cover all exposed surfaces with straw and canvas.	Cover with straw and canvas to prevent early heat loss.	Enclose forms with tarpaulins and heat with steam or salamanders.
	Service strength at	48 hours	Light duty in 72 hours. Heavy duty, 5 to 7 days.	72 hours
For Cold Weather When Temperatures Fall Below 20° F.	**Protection of Materials**	Heat all water and aggregates. Water not above 180°-190° F. Remove all snow and ice from forms.	Heat all water and aggregates. Water not above 180°-190° F. Deposit concrete on subgrade free of frost.	Heat all water and aggregates. Water not above 180°-190° F. Deposit concrete in forms free of ice and snow. Warm forms with steam if available.
	Temp. of Concrete when placed	70° F.	90° F.	80° F.
	Curing period	24 to 72 hours	48 to 72 hours	48 to 72 hours
	Protection during curing period	Provide heat wherever possible—cover all exposed surfaces with straw and canvas.	Cover with heavy straw layer and canvas to prevent early heat loss.	Enclose forms with tarpaulins and heat with steam or salamanders.
	Service strength at	72 hours	Light duty in 72 hours. Heavy duty, 5 to 7 days.	72 hours

Note.—The range of curing period suggested is intended to cover concretes of various water ratios. Water contents around 5 gallons per sack will require but ⅓ to ½ the curing period necessary for concretes using 8 to 9 gallons per sack.

LEHIGH
EARLY STRENGTH
CEMENT

DETERMINING SERVICE STRENGTH AT LOW TEMPERATURES

"For concrete exposed to temperatures below freezing, the strength at any time after the period of initial curing depends primarily on the strength developed during the initial curing period." This quotation is from the conclusions drawn by A. G. Timms and N. H. Withey after an extensive series of tests conducted by them to determine temperature effects on compressive strength of concrete with particular reference to such conditions as prevail when concreting in cold weather. (Journal of the American Concrete Institute, Vol. 5, No. 3.)

The table opposite is made up from figures taken from these data and makes a direct comparison of concrete strengths developed by normal Portland Cement cured 3 days at 70° before exposure and High Early Strength Cement cured 1 day at 70° before exposure.

Early Service Strengths

Note particularly the definite strength advantage of the High Early Strength cements when subjected to 50° F. and 33° F. temperatures notwithstanding the 48-hour reduction in heat curing. The concrete used in the tests was made with various mixing water contents from 4½ to 9 gal. per sack of cement.

With the manifest advantages which result in expensive curing time saved when Lehigh Early Strength Portland Cement is used, it is well to consider, when designing any concrete mixture for placing in cold weather, the facts that the strength of concrete at any age decreases as the amount of mixing water increases; and that the rate of hardening of any concrete mixture slows up as the temperature of the concrete lowers.

Low Water Ratio Advisable

This table demonstrates very clearly the advisability of holding the water content down. Nine gallons of water per sack of cement is seldom necessary on average work; it makes very wet concrete, and always definitely reduces the early strength of all concretes regardless of temperatures or exposure. During cold weather such high water contents can greatly retard job progress. Note that 3 added gallons of water reduces the compressive strength of all concretes by approximately 50% (6 to 9 gallons).

Below 20° F.

The strength values for concrete exposed to 16° F. after curing for 24 hours at 70° F. are particularly significant. It will be noted that safe service strengths are attained for concrete made with high early strength portland cement except when the water content is high. When as much water as nine gallons per sack of cement is used, it is manifest that more than 24 hours' curing should elapse before removal of forms when exposed to temperatures below 20° F. Reference to the table on page 7 will indicate that curing periods of 48 hours are recommended except for heavy mass sections.

SUGGESTIONS FOR COLD WEATHER CONCRETE WORK

Heating Materials

Mixing water and aggregates should be heated, whenever necessary, to insure the concrete leaving the mixer at 60° or better. Aggregates not less than 40° and water about 180° will accomplish this. Aggregates in frozen lumps should be thawed independently—no materials containing frozen lumps should be permitted to enter the mixer. Water is easily heated by running a steam pipe into the water barrel, or by piping the water through a coil mounted over a fire on the ground.

Aggregates are best heated by 1½" steam pipes laid as a grill under the piles or by a 6 ft. length of perforated pipe inserted into the pile. A fire built inside of a large pipe (or section of metal culvert) will heat aggregates quickly for small jobs. Pile the cold aggregates against it; sand on one side and stone on the other.

Mixing and Transporting

Thorough mixing is necessary and permits the use of the minimum water content to obtain the desired strength concrete. The mixing should be done as close to the point of placing as possible. When placed, the concrete should have a temperature of from 60° F. to 90° F., depending upon the air temperature and nature of the job (see table on page 7). When water and aggregates are very hot, it is advisable to mix these together first before adding the cement.

Placing

Forms should be entirely free from ice and snow. A steam jet or blow torch may be used for this purpose. It is helpful to warm the forms and any steel reinforcing by means of live steam if it is available.

Placing should be accomplished as rapidly as possible since the heat loss is greatest at this time. Immediately after placing, protection should be provided as demanded by the air temperatures and job condition (see table on page 7).

Protection

Salamanders, tarpaulins, etc., should be available to maintain the proper moist curing temperature for the length of time required.

The extra effort necessary to maintain adequate heat protection will materially assist in the hardening of the concrete. Provision should be made for the maintenance of the proper curing temperature against the contingency of sudden temperature drops.

Too rapid drying out of the concrete should be avoided under all conditions, as is usual in concrete curing at normal temperatures.

Frozen Concrete

Alternate freezing and thawing of the concrete before it has reached the safety point must be avoided. If for any reason there is a possibility that the concrete has frozen, tests should be made before forms are entirely removed. To make such a test, steam, hot water, or the flame from a blow torch should be applied to the concrete. If the concrete has been frozen, upon the application of such heat it will soften at once, due to the melting of the ice. If the concrete has not been frozen, the application of heat will not affect the surface.

Temperature Records

Under some job conditions it may be desired to keep detailed dated and timed temperature records at regular intervals of the air temperature; temperature of concrete when mixed, and as deposited; temperature under the protection provided or within the enclosure. Such records would show the favorable or unfavorable conditions to which the concrete had been subjected and be of assistance in determining how soon forms could be removed.

CONSIDER POSSIBLE SAVINGS WITH LEHIGH EARLY STRENGTH PORTLAND CEMENT

1. The per day savings from the curtailed use of heating plant for aggregate and water.
2. The reduced cost of lumber because of fewer forms required.
3. One-half to one-third normal cost of heat curing considering:
   Less housing or tarpaulin protection
   Fewer salamanders and less fuel
4. Reduced expense because of earlier job completion: increased job efficiency; reduced overhead; reduced interest charges; earlier revenue from completion.

Building owners, bankers, and investors should be aware of the benefits which accrue from a broad point of view of eliminating the seasonal peaks in construction.

1. Steady employment of capital in building.
2. Year-round employment of manufacturing facilities contributing to the construction industry.
3. A more even flow of heavy freight.
4. Reduced carrying charges and loss of rental from delayed construction when building has been definitely decided upon.
5. The ability to plan and execute alterations and repairs at a time most advantageous to the owner.

COMPARATIVE STRENGTH VALUES

CONCRETE MADE WITH VARIOUS WATER RATIOS EXPOSED TO LOW TEMPERATURE RANGE

	Compressive Strength in lbs. per sq. in. at	Exposed to 50° F.		Exposed to 33° F.		Exposed to 16° F.	
		After 70° F. Curing		After 70° F. Curing		After 70° F. Curing	
		for 3 days	for 1 day	for 3 days	for 1 day	for 3 days	for 1 day
		Normal Portland Cement	High Early Strength Cement	Normal Portland Cement	High Early Strength Cement	Normal Portland Cement	High Early Strength Cement
4½ Gals. Per Sack	1 day		**2660**		**2660**		**2660**
	3 days	3710	**4200**	3710	**3560**	3710	**3400**
	7 days	4400	**5130**	4160	**4910**	4030	**3470**
	28 days	5890	**6850**	5180	**6310**	4340	**3870**
6 Gals. Per Sack	1 day		**1670**		**1670**		**1670**
	3 days	2430	**3380**	2430	**2420**	2430	**2140**
	7 days	3070	**4440**	2710	**3470**	2480	**2380**
	28 days	4090	**5240**	3710	**4990**	2740	**2440**
9 Gals. Per Sack	1 day		**780**		**780**		**780**
	3 days	1060	**1680**	1060	**1300**	1060	**1100**
	7 days	1460	**2320**	1240	**1810**	1120	**1160**
	28 days	1920	**3320**	1680	**2680**	1130	**1270**

From "Temperature Effects on the Strength of Concrete."—Timms & Withey—A.C.I. Proceedings, Vol. 30

SOME CASES from practice

Lehigh Early Strength Cement was used for two reasons: as a safeguard against night temperatures down to 25° F., and to reduce time of traffic hindrance. Concrete base for drainage culvert was poured one day, brick sidewalls, laid up with Lehigh Early Strength Cement, completed the second day, reinforced concrete slab poured the third day—excavation filled and road opened to traffic on the fourth day. Since state highway rules prohibited closing the road, one-half was done at a time. No cost for heat protection and employment of night watchmen for eight days less were savings, although public convenience was of first importance.

STORM WATER DRAINAGE PROJECT,
Borough of Narberth, Pa.

Top speed in winter was obtained with Lehigh Early Strength Cement for footings, foundations and floors. Form removal and use of concrete in 36 hours expedited the whole job. Heat protection costs were negligible and quick re-use reduced form costs.

ADMINISTRATION BUILDING AND GARAGE,
South Jamaica, N. Y.
OWNER: Green Bus Line, Inc.
ARCHITECT: Lama & Proskauer, Brooklyn, N. Y.
CONTRACTOR: Louis Del Gaudio Construction Co., Inc., Brooklyn, N. Y.

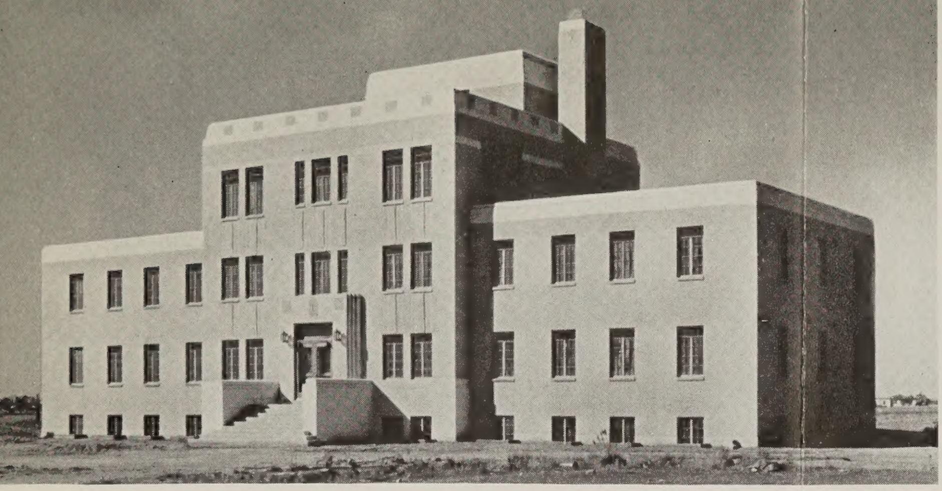
Freezing temperatures did not slow up this job. Concrete up to the first floor was already in place when cold weather came. A switch to Lehigh Early Strength Cement, for the second and third floor concrete slabs, offset the danger of frozen concrete. Curing cost was lowered, construction uninterrupted all winter, and the building ready for spring occupancy.

TOMPKINS COUNTY MEMORIAL HOSPITAL,
Ithaca, N. Y.
ARCHITECT: A. N. Gibb, Ithaca, N. Y.
ENGINEER: L. C. Urquhart, Ithaca, N. Y.
CONTRACTOR: Ward Construction Co., Ithaca, N. Y.

Six weeks behind schedule and severe winter weather were serious problems. Lehigh Early Strength Cement, instead of normal cement, for concrete columns, beams and slabs, was the solution. Concrete met full strength requirements 23½ days sooner. Forms were stripped as much as 14 days earlier—quick re-use reduced form cost. Heat curing costs were heavily reduced. The whole job was expedited, finished on schedule.

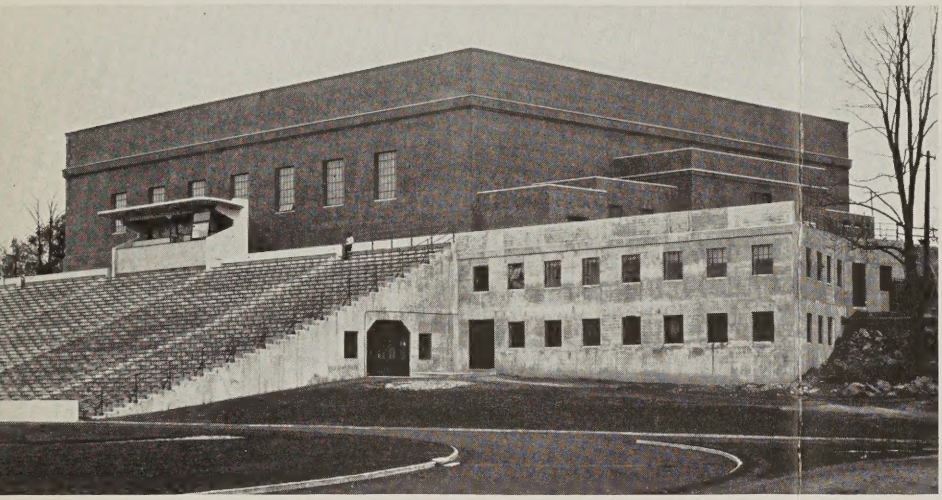
TUBERCULOSIS SANATORIUM, Butler, Pa.
ARCHITECT: Edw. B. Lee, Pittsburgh, Pa.
CONTRACTOR: Matthew Cummings Co., Boston, Mass.

AVERY CLASSICS



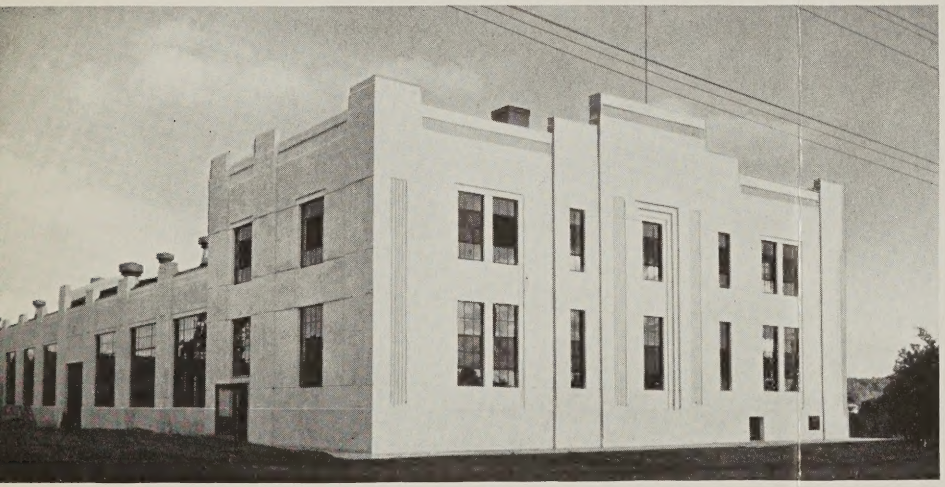
Cold weather construction of this reinforced concrete frame building was made safe and economical by the use of Lehigh Early Strength Cement. Concrete quickly cured beyond the danger of frost damage and forms were stripped in one-third the usual time. Reduced form costs, minimum heat protection costs, and reduced overhead because of quicker completion were the advantages.

HOSPITAL, Clovis, New Mexico
GENERAL CONTRACTORS: Ellis, Nicholson & Cramer, Inc., Oklahoma City, Okla.



Figuring the job both ways, resulted in the use of Lehigh Early Strength Cement for this winter job. Compared with the use of normal cement, quicker curing cut time and cost of heat protection two-thirds. Quick re-use of forms caused lower form cost. In all, $300 was saved and the whole job was finished 28 days earlier.

BASEBALL CAGE AND FIELD HOUSE,
University of New Hampshire, Durham, N. H.
ARCHITECT: Professor E. T. Huddleston,
U. of N. H.
ENGINEER: L. M. Hersum, Boston, Mass.
CONTRACTOR: Swanburg Construction Co.,
Manchester, N. H.



Temperatures ranged from 20° F. below zero to 20° F. above. With Lehigh Early Strength Cement, minimum heat protection reduced curing cost by $600. Forms were stripped in 3 days—this quick strength reduced form requirements one-half and saved $500. Sixty days' earlier completion saved $900 for two supervisors' salaries. Total cash saving, $2000.

POLK COUNTY HIGHWAY GARAGE AND OFFICE BUILDING, Balsam Lake, Wis.
ARCHITECT: E. F. Klingler, Amery, Wis.
CONTRACTOR: James Johnson, Amery, Wis.

After building foundations with normal cement, winter weather and urgent completion caused a change to Lehigh Early Strength Cement. Pouring was at varying winter temperatures until completion of concrete in January. Aggregates and water were heated but protection during curing was minimum. The contractor reports savings in heat protection costs, form costs and overhead. Lehigh Early Strength Cement was also used in brick mortar as a frost safeguard.

THE GRAYCO APARTMENTS,
Harrisburg, Pa.
ARCHITECT: William Lynch Murray,
Harrisburg, Pa.
ENGINEER: Alphonse Treo, Harrisburg, Pa.
CONTRACTOR: S. W. Shoemaker & Sons,
Harrisburg, Pa.
Ready mixed concrete furnished by
Pennsylvania Supply Co., Harrisburg, Pa.

LEHIGH

NORMAL CEMENT
EARLY STRENGTH CEMENT
MORTAR CEMENT

LEHIGH PORTLAND CEMENT COMPANY
LEHIGH
ALLENTOWN, PA.-CHICAGO, ILL.
94 LBS. NET
LEHIGH CEMENT
HIGH EARLY STRENGTH
LEHIGH
HIGH EARLY STRENGTH PORTLAND CEMENT
LEHIGH PORTLAND CEMENT COMPANY
ALLENTOWN, PA. CHICAGO, ILL.
94 LBS. NET
LEHIGH MORTAR CEMENT
70 LBS. NET
LEHIGH MORTAR CEMENT
LEHIGH PORTLAND CEMENT COMPANY
ALLENTOWN, PA. CHICAGO, ILL.

LEHIGH PORTLAND CEMENT COMPANY

Allentown, Pa., Chicago, Ill., Spokane, Wash.